Purpose of Meeting

GPM

1. Stimulate Existing & Initiate New Partnerships; Assess Partner Readiness & Identify Assets
   - a. scientist engagement
   - b. space hardware & associated data streams
   - c. high quality validation supersites & associated data streams
   - d. high quality regional raingage networks & associated data streams
   - e. additional precipitation & ancillary data streams
2. Exchange Information on Major Scientific Objectives
3. Discuss Critical Engineering & Technical Issues
   - a. orbit architecture
   - b. radiometer frequencies
   - c. general algorithm design
   - d. radiation-cloud modeling
   - e. design & focus of validation system

GPM's Key Science Theme

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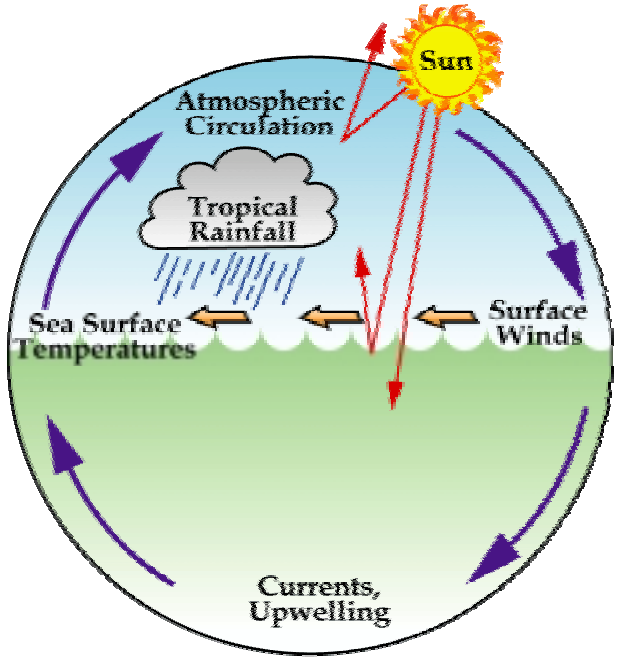
Global Water & Energy Cycle

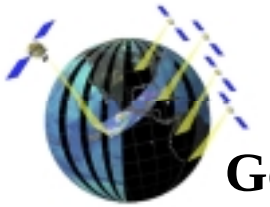
- **GOAL: Observe, understand, & model Earth system to learn how it is changing, & consequences for life on Earth.**
- **SOLUTION: Establish existence (or absence) of trend in rate of global water cycle -- acceleration would lead to faster evaporation, increased global average precipitation, & general increase in extremes, particularly droughts & floods.**

GPM will extend TRMM's observations of rainfall rates to higher latitudes thus yielding more complete and accurate representation of global water cycle.

Advanced rainfall measurement core satellite will make detailed & accurate estimates of precipitation structure & microphysical properties -- while constellation of drone satellites flying passive microwave radiometers will provide required temporal sampling of highly variable precipitation systems.



Uncertainty in global tropical rainfall estimates has been reduced from 50% to 25% using TRMM data



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Global Water Budget & Water Cycle

General Equation

$$S = P - E - DIV - RO$$

Oceanic Water Budget

total water tendency (vapor or cloud water)		3D vapor or cloud water divergence		evaporation sublimation		condensation deposition		vertical divergence of vertical eddy transport of vapor or cloud water
$\check{Z}\overline{q_v(p)}/\check{Z}t$	$= -\nabla\bullet\overline{\vec{V}(p)\,q_v(p)}$	$-\ \check{Z}\overline{\omega\,q_v(p)}/\check{Z}p$	$+$	$\overline{e(p)}$	$-$	$\overline{c(p)}$	$-$	$\check{Z}\overline{[q_v(p)']\,\omega(p)'}/\check{Z}p$
$\check{Z}\overline{q_w(p)}/\check{Z}t$	$= -\nabla\bullet\overline{\vec{V}(p)\,q_c(p)}$	$-\ \check{Z}\overline{\omega_c\,q_c(p)}/\check{Z}p$	$-$	$\overline{e(p)}$	$+$	$\overline{c(p)}$	$-$	$\check{Z}\overline{[q_v(p)']\,\omega_c(p)'}/\check{Z}p$

↓ VERTICALLY INTEGRATE ↓

$\overline{W_t}$	$=$	$-\ \overline{\vec{U}\bullet\nabla\,W}$	$-$	$\overline{\vec{U}\bullet\nabla\,W_c}$	$+$	$\overline{E}$	$-$	$\overline{P}$
column vapor & cloud water storage		vapor advection		cloud water advection		evaporation		precipitation

Continental Water Budget -- Not Same Problem

$\overline{S}$	$=$	$-\ \overline{\vec{U}\bullet\nabla\,q_l}$	$-$ RO	$-$ BF	$+$	$\overline{P}$	$-$	$\overline{E}$
soil moisture/ surface water/ surface snow/ice storage		interflow (water advection) [bulldozers] [dump trucks] [nuclear bombs] [continental drift]	surface runoff & base flow & recharge		precipitation deposition tree leaf-needle drip canopy snow blowoff		evaporation [ground/leaf/snow] transpiration or ET sublimation	

NASA ESE Strategy for Earth System Science

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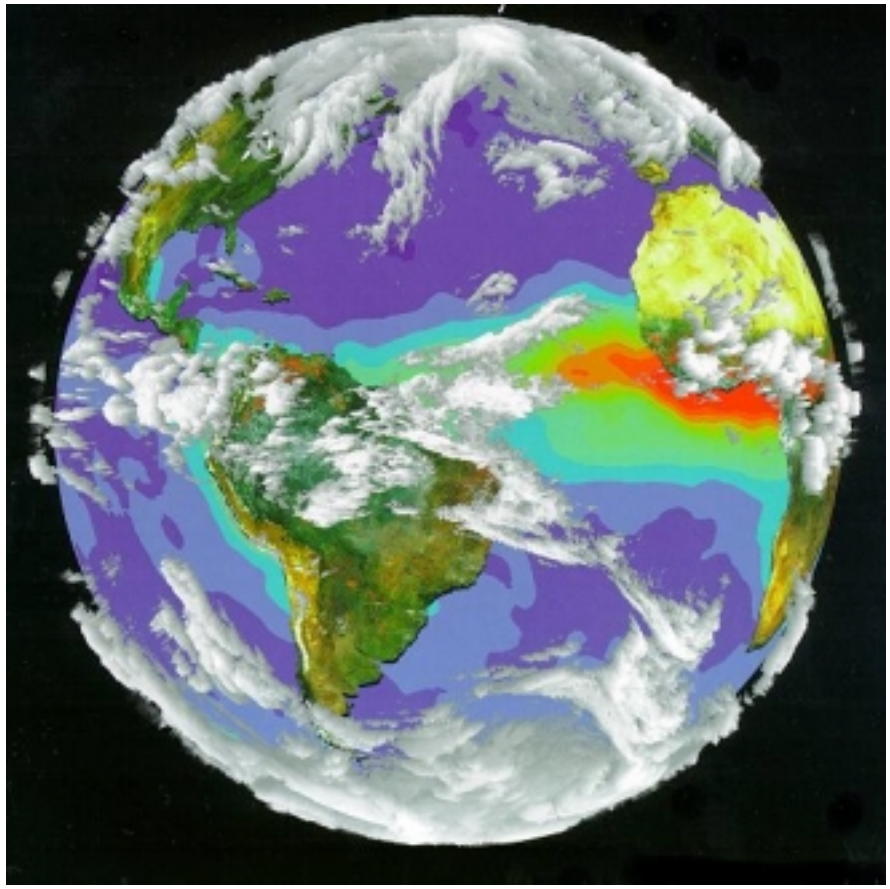
Forces Acting on Earth System



Earth System Response

Impacts

How is Earth changing & what are consequences for life on Earth ?

1. *How is global Earth system changing ?*
2. *What are primary causes of change of Earth system ?*
3. *How does Earth system respond to natural & human-induced changes ?*
4. *What are consequences of change in Earth system for human civilization ?*
5. *How well can future changes in Earth system be predicted ?*

Climate Feedback

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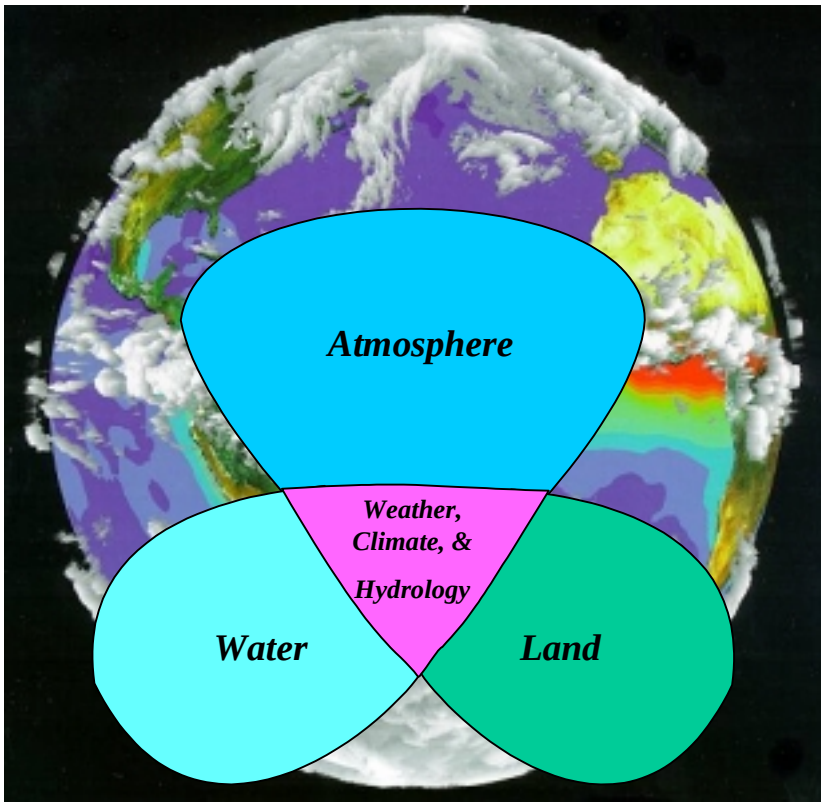
GPM's Nine (9) Science Discipline Areas



(1) Climate Diagnostics: refining & extending precipitation climatologies including snow climatologies; detecting statistically significant global & regional precipitation trends

(2) Global Water & Energy Cycle / Hydrological Predictability: global water & energy cycle (GWEC) analysis & modeling; water transports; water budget closure; hydrometeorological modeling; fresh water resources prediction

(3) Climate Change / Climate Predictability: climate-water-radiation states; climate-change analysis & prediction; GWEC response to climate change & feedback;

(4) Data Assimilation / Weather & Storms Predictability: rainfall data assimilation; global-regional scale NWP techniques

(5) MBL Processes: air-sea interface processes & surface flux modeling; ocean mixed layer salinity changes

(6) Land Processes: land-atmosphere interface processes & surface flux modeling; integrated surface radiation-energy-water-carbon budget process modeling

(7) Coupled Cloud-Radiation Models: diagnosis of cloud dynamics, macrophysical/microphysical processes, & response of 3D radiation field; parameterizing microphysics & radiative transfer in nonhydrostatic mesoscale cloud resolving models

(8) Retrieval/Validation/Synthesis: physical retrieval of precipitation & latent heating; algorithm calibration & products normalization; algorithm validation & quantification of uncertainty; synthesis of validation for algorithm improvement

(9) Applications/Outreach: weather forecasting; flash flood forecasting; news media products; educational tools

GPM Reference Concept

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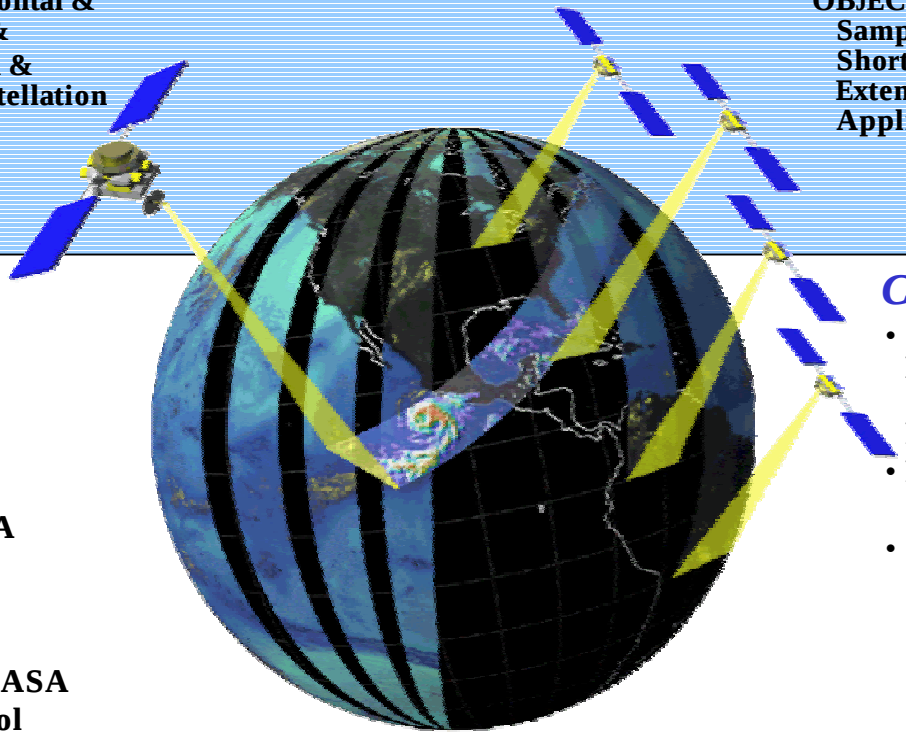
OBJECTIVE: Understand Horizontal & Vertical Structure of Rainfall & Its Microphysical Nature. Train & Calibrate Algorithms for Constellation Radiometers.

OBJECTIVE: Provide Sufficient Sampling to Reduce Uncertainty in Short-term Rainfall Accumulations. Extend Scientific and Societal Applications.



Core Satellite

- TRMM-Like S/C, NASA
- H2A Launch, NASDA
- Non-Sun Synchronous Orbit
  - ~ 65° Inclination
  - ~450 km Altitude
- Dual Frequency Radar, NASDA
  - Ku & Ka Bands
  - ~ 4 km Horizontal Resolution
  - ~250 m Vertical Resolution
- Multifrequency Radiometer, NASA
  - 10.7, 19, 22, 37, 85 GHz V&H Pol

Constellation Satellites

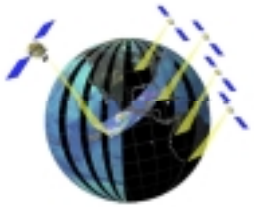
- Dedicated Small or Pre-existing Experimental & Operational Satellites with PMW Radiometers
- Revisit Time
  - 3-Hour goal
- Sun-Synchronous Polar Orbits
  - ~600 km Altitude

Precipitation Validation Sites

- Selected & Globally Distributed Ground- Based Supersites (polarimetric radar, radiometer, raingages, & disdrometers) & Dense Regional Raingage Networks

Global Precipitation Processing Center

- Produces Global Precipitation Data Product Streams Defined by GPM Partners



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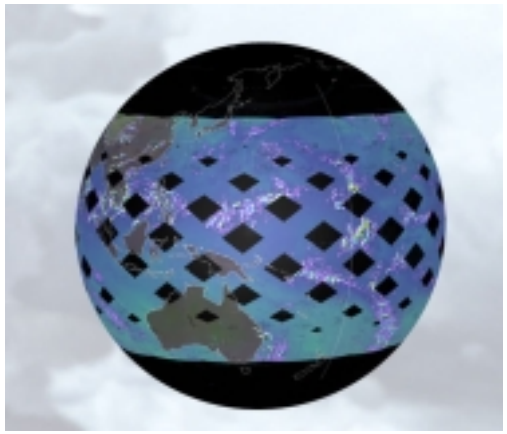
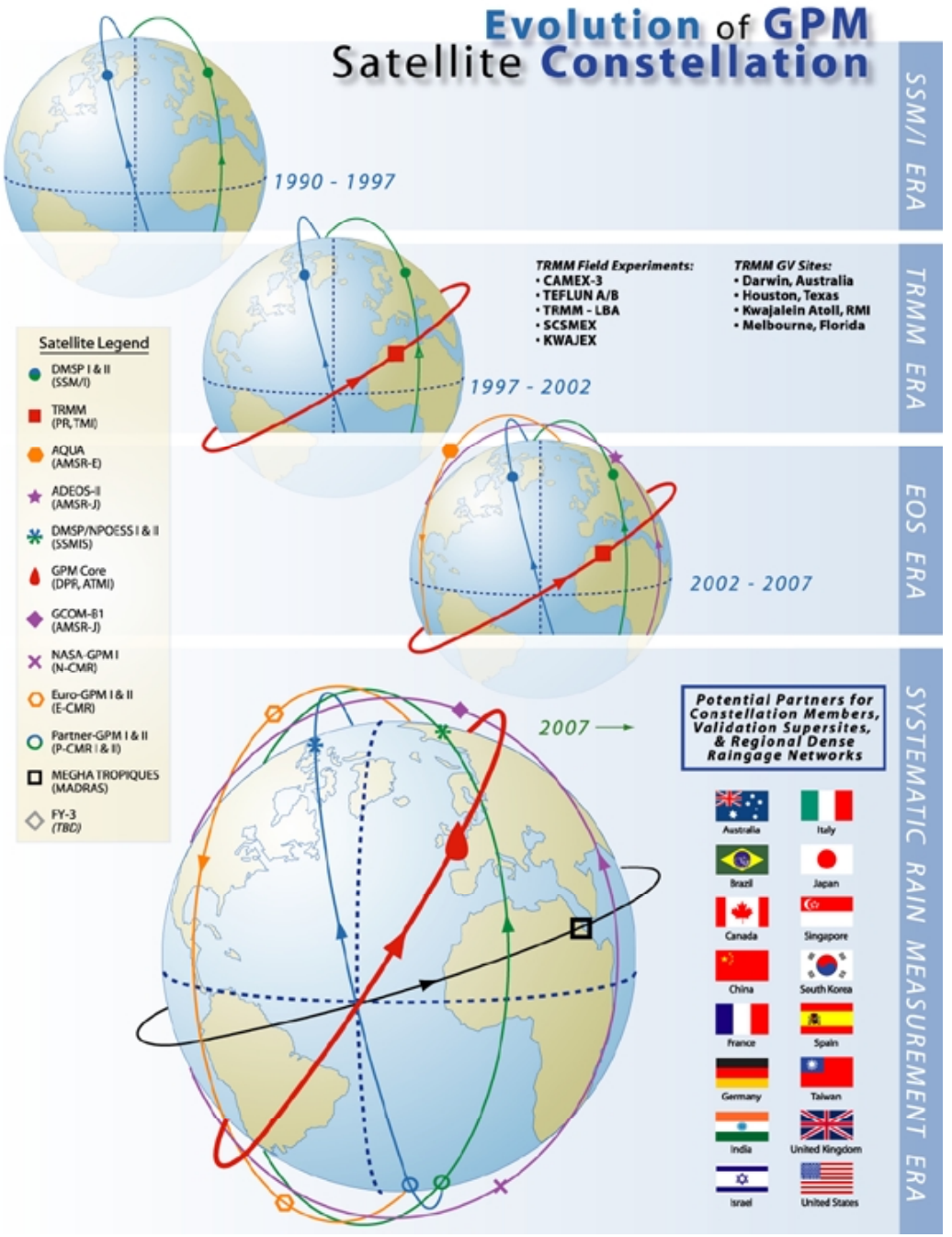
TRMM 1-day coverage





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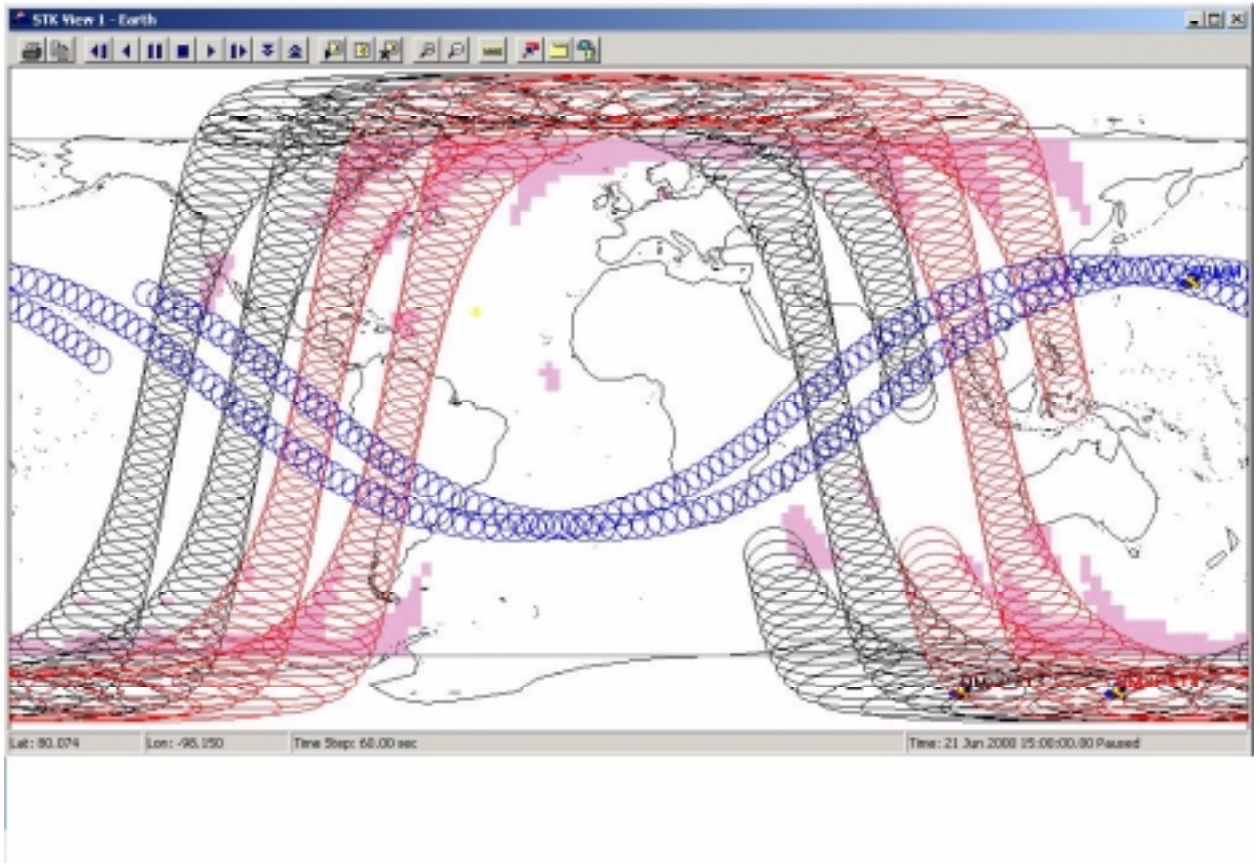
TRMM Era Constellation Coverage



3-hour sensor ground trace

TRMM + DMSP(F14) + DMSP(F15)

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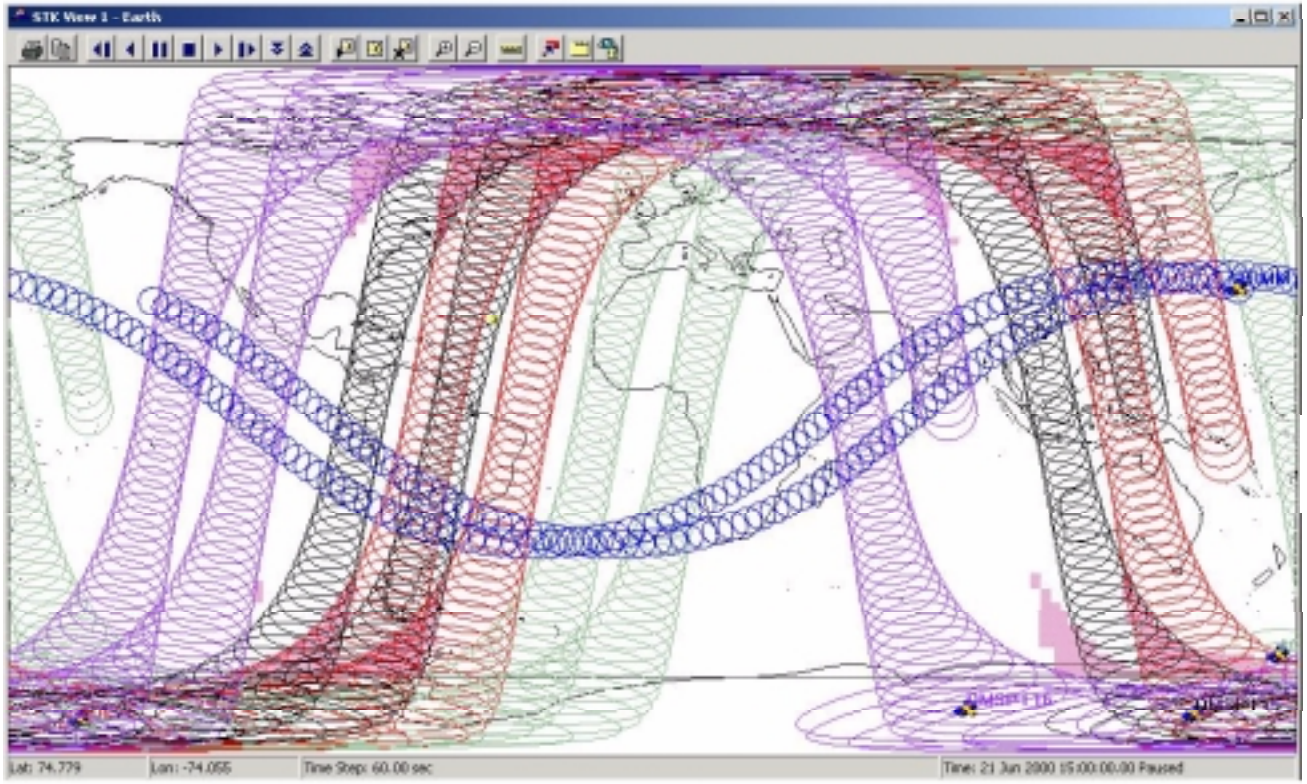
EOS Era Constellation Coverage



3-hour sensor ground trace

TRMM + DMSP(F15) + DMSP(F16) + AQUA + ADEOS II

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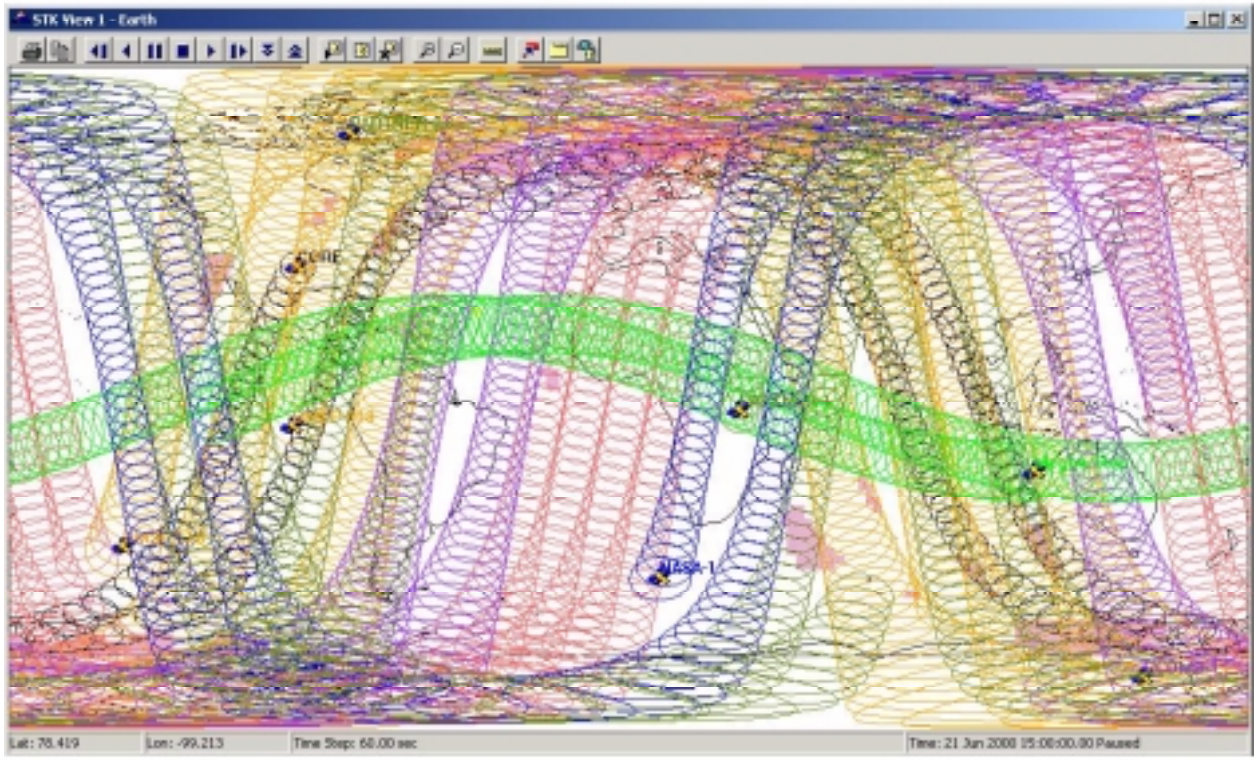
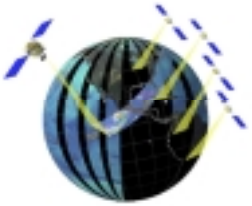
GPM Systematic Measurement Coverage (Core + 6 constellation members)



3-hour sensor ground trace

GPM Core + MEGHA-TROP + DMSP(F18) + DMSP(F19) + GCOM-B1 + NASA-GPM I + Euro-GPM I & II + Partner-GPM I & II



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Global Precipitation Mission (GPM) Purpose

1. Measure Rainfall Accurately, Globally, & Often
2. Stimulate GWC Research Across Scale Spectrum
3. Underwrite Compelling Rainfall-Based Applications
4. Improve Space Technology for Rainfall & Synergistic Measurements
5. Deliver Effective Education/Media/Commercial Outreach Program

Better Rain Measuring	Better Sampling	Better Methodologies
DSD-centric with physical validation	constellation design & GEO data infusion	marriage of measurements & prediction models

Overarching Science & Technology Goals

Technology

- advance multiparameter rain radar instruments
- advance SA/RA rain radiometer instruments
- move toward operational space-based rain measuring system

Research

- understand & quantify GWC dynamics & variability of atmos-bio-cryo-hydrospheres
- seek closure of mass-energy budgets at basin scales
- understand relationships between GWC & climate and underlying predictability

Applications

- improve QPF of landfalling TCs & MLCs
- improve flash flood forecasts of alpine storms
- improve prediction of fresh water resources